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1 ② Progress Report for January 1963
EVALUATION OF REGENERATIVE FUEL CELL

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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DOTS

Prepared by

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OTS:PRICE

XEROX

MICROFILM

\$ 1.10 ph
\$ 0.80 ref.

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1. INTRODUCTION

Progress was made during the month of January on the electrolyte storage experiments. These experiments are being made to test the feasibility of electrolyte storage in the region behind the electrodes. If this can be accomplished satisfactorily, then regenerative fuel cells with much higher energy to weight ratios than previously possible can be developed. Experiments to date indicate that under conditions of moderate charging and discharging current densities the method is feasible.

Additional studies of the effect of KOH electrolyte concentration on cell performance have been made. The recent results confirm some aspects of earlier studies and are more complete.

Experiments have been designed, and the apparatus is now being built, for the purpose of measuring gas diffusion rates through the electrolyte-asbestos layer. Charge retention of a hydrogen-oxygen fuel cell is directly determined by these diffusion rates.

AUTHOR

2. ELECTROLYTE CONCENTRATION DEPENDENCE

Numerous attempts to duplicate our original results on the effect of KOH electrolyte dependence on cell polarization have been made. (EOS Report 3310 Q-1). Some features of that work have been verified, but the low cell polarization at high current densities with 10% KOH solutions have not been observed since the original work. The recent experiments have been made with a cell containing reference electrodes, whereas the former experiments were not.

Fig. 1 shows the results of one such series of measurements of electrode polarizations for 10%, 35%, and 55% KOH. The polarizations are generally somewhat higher than usual, due in part to the fact that the electrolyte had not been treated with $\text{Ba}(\text{OH})_2$, and in part because the electrodes had been used in many previous experiments. It will be noted that the shape of the oxygen electrode polarization curve at 55% KOH, (and therefore the shape of the total cell polarization curve since the hydrogen curve is approximately linear), is very similar to the cell polarization curve reported previously. These results are usually, but not always, found. With 10% KOH solution on either charge or discharge the polarizations are invariably quite high, in sharp contrast to the earlier results.

The importance of studies concerning the effect of electrolyte concentration on cell performance lies in the fact that a rechargeable hydrogen-oxygen fuel cell must operate over a wide concentration range. More electrolyte can be stored in a given volume if the concentration is lower, and the fraction of electrolyte which is usable water is greater, but other considerations, such as cell performance, may dictate higher initial concentrations.

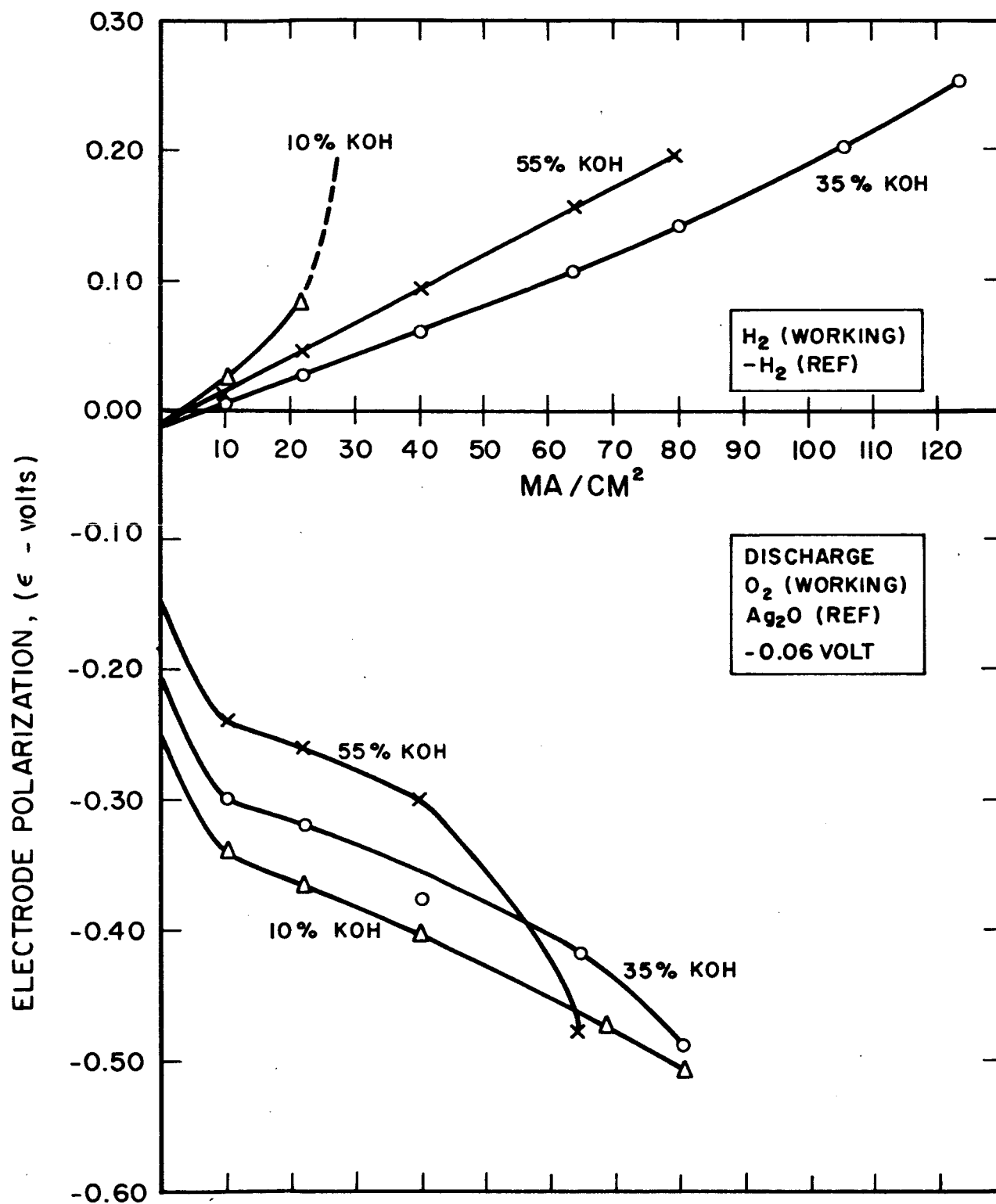


FIG. 1 EFFECT OF ELECTROLYTE CONCENTRATION ON CELL PERFORMANCE

3. ELECTROLYTE STORAGE EXPERIMENTS

Some results of the electrolyte storage experiments are shown in Fig.

2. The cell used in these experiments was designed to test the feasibility of electrolyte storage behind the electrodes, and was described in a previous report (EOS Report 3310 Q-2). If the method is proven feasible, higher electrolyte storage can be attained without any loss in cell performance, since the electrode spacing is not increased.

The curves of Fig. 2 are described in Table I. It will be noted in curve C that charging was begun when the cell was not completely discharged. In this case charging was first done along curve A, then the cell was discharged as far as it would go, and then charging was done along curve C to bring it back to a fully charged condition.

TABLE I

Description of Curves for Fig. 2

<u>Curve</u>	<u>Charge or Discharge</u>	<u>Temp.</u>	<u>Current Density</u>
A	Charge	Room Temp.	25 ma/cm ²
B	"	"	20 "
C	"	"	25 "
D *	Discharge	"	20 "
E	"	"	20 "
F *	"	"	40 "
G	"	70°C	40 "

* Modified screens behind the electrodes

The second time the cell was charged the polarization was much lower. This may be an indication that changes in the matrix occur during the initial charge and discharge which improve its ability to transport electrolyte in and out of the electrode region.

Experiments were also conducted to test the feasibility of picking up electrolyte from the back surface of the electrodes. Five holes, each about 3/16 inch in diameter, were cut in the nickel screens behind the electrodes and filled with asbestos. The results are shown in curves D and F. It will be noted that D is a real improvement over E and also that curve F (a room temperature experiment), was slightly better than G (a 70°C experiment). The latter two discharge curves were run without interruption, while the other two discharge curves had

PERCENT OF TOTAL WATER

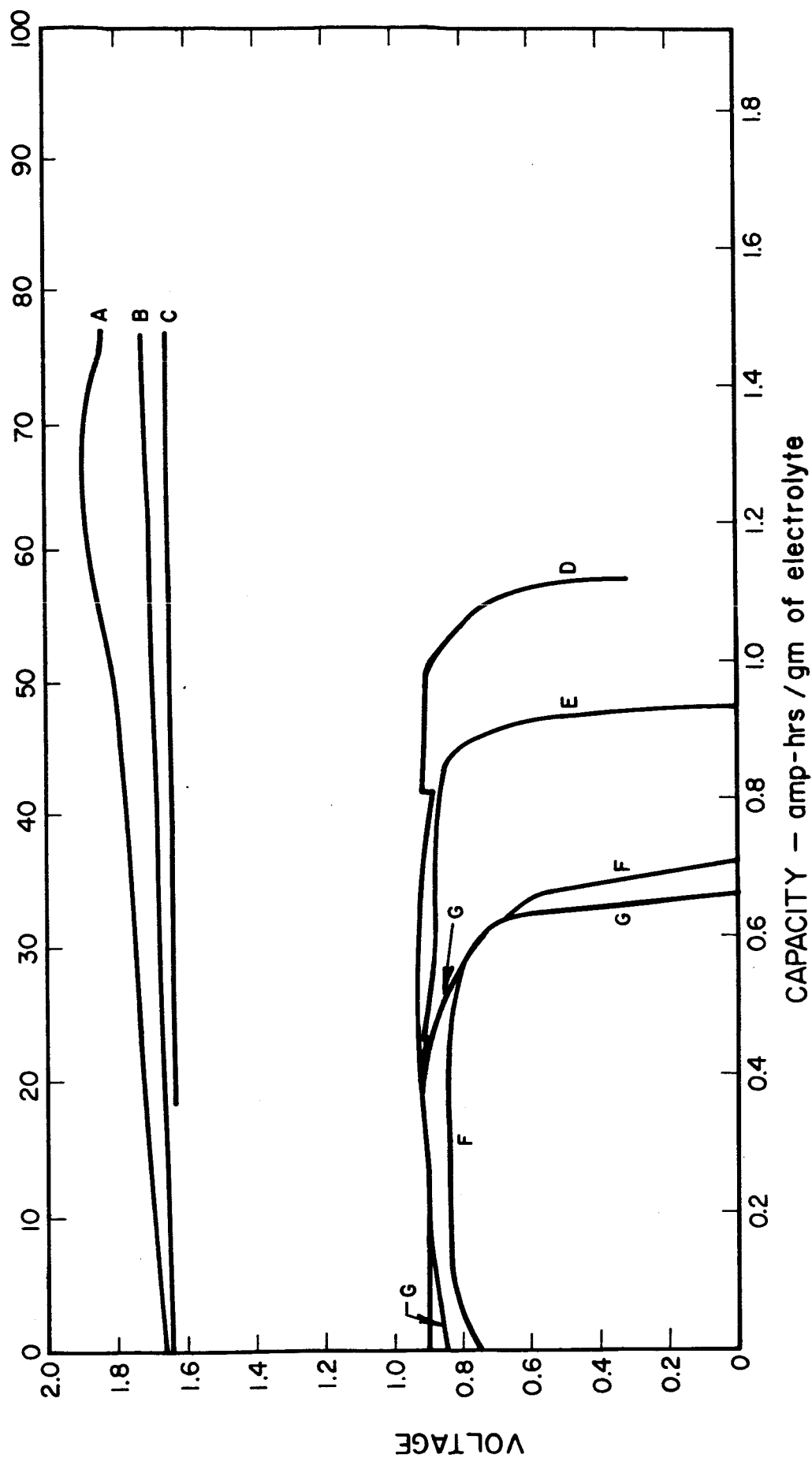


FIG. 2 ELECTROLYTE STORAGE EXPERIMENTS

two breaks each, when the cells sat overnight. This was necessary because of the length of time involved in discharging at 20 ma/cm^2 . At one place on curve D and on curve E it will be noted that the cell voltage had begun to drop. The discharge capacity would have been noticeably shorter had the cells not been allowed to recuperate on those two runs.

The pressure during discharge was 90 psig. in all cases, but the charging was done to the atmosphere and was continuous in all cases. In charging the cells to the atmosphere there was no possibility that gas recombination would occur, and a knowledge of the exact state of charge was therefore possible.

The results of the experiments to date show unequivocally that the electrolyte stored in the region behind the electrodes is available, at least to some extent, for use in the cell. The total weight of 35% KOH solution in the cells was 6.2 gm. The total amount of electrolyte stored in the cell, exclusive of that behind the electrodes, is enough for only about 3.4 amp - hours. By multiplying amp-hours per gram in Fig. 2 by 6.2 it is seen that all curves exceed 3.4 amp - hours.

4. CHARGE RETENTION STUDIES

Since charge retention is determined by the rate of gas diffusion through the electrolyte bed, an experiment has been designed to measure gas diffusion rates through the electrolyte held in an asbestos matrix. Methods used previously to measure gas diffusion rates for materials such as plastic films or membranes are not applicable to the present problem since equal total pressures must be maintained at both sides of the diffusion barrier.

The apparatus is now being built for these experiments. The experiment has been designed so that a pressure balance to within about 0.03 psi will be maintained during the course of a determination. The principle is based on the assumption that hydrogen diffusion rates will be greater than those of either oxygen or nitrogen. A diffusion cell will first be set up with hydrogen on one side and nitrogen on the other. The difference in diffusion rates for these two gases will be measured by noting the volume increase on the nitrogen side as a function of time. The reading will be made in a horizontal capillary tube containing mercury for the indicating liquid. The mercury is contained in a manometer with a large diameter vertical arm and a small diameter (indicating) horizontal arm. Since these measurements will give only the difference in diffusion rates, at the conclusion of each of these experiments the gas in the nitrogen side will be analyzed for hydrogen by the cupric oxide oxidation method. This is the reason hydrogen vs. oxygen cannot be measured directly. Further experiments of oxygen vs. nitrogen will then be made. Since the absolute diffusion rate for hydrogen will have been determined (and therefore nitrogen) this latter experiment will also yield the absolute rate for oxygen.

5. FUTURE PLANS

During February the following projects will be completed:

1. Electrolyte storage experiments
2. Charge retention studies
3. Cycle efficiency determinations
4. Raney nickel experiments

For the electrolyte storage experiments, more uninterrupted discharge curves will be obtained and some new electrode configurations will be studied. The Raney nickel experiments will be run to determine the ability of this material to take up hydrogen in the manner of palladium.

6. APPROXIMATE MANHOURS AND DOLLAR EXPENDITURES AND COMMITMENTS FOR PERIOD OF JANUARY 1963

MANHOURS

J. Rowlette, Project Supervisor	160 hours
D. Lee, Chemist	160 hours
Bernard Wilner	8 hours

DOLLAR EXPENDITURES AND COMMITMENTS:	\$2,928.31
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